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Approximation of the Dependency of Trace Elements Concentrations in Internal Media upon their Contents in Environment Objects

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Abstract
Models that demonstrate the dependency of a trace element content in the internal milieu of an organism upon that in external media objects of the environment were developed to identify dominant factors in ecology-mediated microelement imbalance in a human body. Based on the sets of experimental data obtained on trace element concentrations in the internal milieu (fluids) of a human body (blood) and accumulating media (hair), external fluids (drinking water), and deposit media (soil and snow cover), the degree of approximation of dependencies captured with different models was estimated, with the most adequate ones chosen. Linear, cubic, logistic, sigmoidal, parabolic functions, a polynomial of the fourth and fifth degrees, the Nelder–Mead optimization algorithm, and a Boltzmann function were applied to evaluate the approximation degree by different models. The selection of internal and external media demonstrating the best approximation results is justified.

Keywords Drinking water · Trace element concentration · Approximation model

1 Introduction

Trace or microelements, despite their relatively low content in the environment, are concentrated in organisms directly proportional to their content in the habitat [1–5]. A specific microelement balance is normally maintained in a human body. An excess of acceptable trace element concentrations in an organism results in dysfunction of many organs and systems [6–8].

Recently large-scale studies have been carried out in various countries that evaluate a microelement imbalance in the human body due to biogeochemical conditions and environmental factors of the place of subjects' residence [9–13].

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Chinese scientists studied the accumulation of trace elements in the hair of inhabitants of Fenghuang in southwest China, which is famous for its mines and shafts. The content of trace elements in soil, drinking water, food products, and air was also assessed [14–16]. There was an accumulation of trace elements in the hair of inhabitants living on the territories adjoining the mines. In addition, there were statistically significant ($p < 0.01$) correlations between the content of cadmium and lead, cadmium and arsenic, lead and arsenic, and selenium and mercury in the hair and in the environment as compared to the control group. Portuguese researchers from the National Institute of Health obtained similar results. They evaluated the content of metals in various dynamic and accumulating media in residents of the Panasqueira mine area in central Portugal [17]. There were significantly increased concentrations of trace elements such as As, Cd, Cr, Mn, and Pb in all biological samples (the hair, fingernails, blood, urine) taken from people living near the mine as compared to the control group. Genotoxicity and immunotoxicity tests also demonstrated statistically significant differences.

Italian scientists carried out a similar extensive study of the trace element spectrum in the scalp hair of children living in different environmental contexts and geographical areas in Sicily [18]. A total of 336 children aged 11–13 years participated in the study, concentrations of 19